

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION  
International Bureau



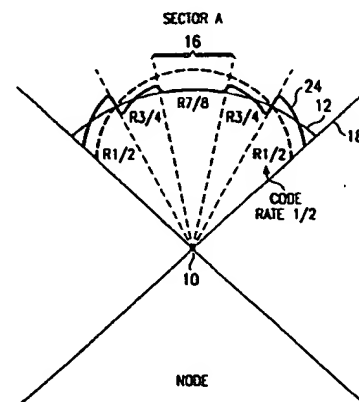
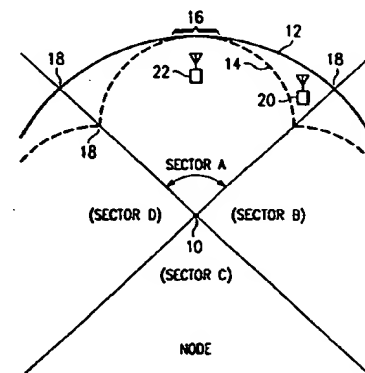
INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification <sup>7</sup> : <b>H01Q 3/26, H04Q 7/36, H04B 7/26, H04L 1/00</b>		A1	(11) International Publication Number: <b>WO 00/21157</b>
			(43) International Publication Date: 13 April 2000 (13.04.00)
(21) International Application Number: PCT/US99/23328			(81) Designated States: AU, CA, JP, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).
(22) International Filing Date: 7 October 1999 (07.10.99)			
(30) Priority Data: 09/167,804 7 October 1998 (07.10.98) US			
(71) Applicant: CISCO SYSTEMS, INC. [US/US]; 170 West Tasman Drive, San Jose, CA 95134 (US).			
(72) Inventors: MYERS, William, K.; Route 1, Box 278A, McKinney, TX 75050 (US). WEINER, Douglas, B.; 5625 Phelps, The Colony, TX 75056 (US).			
(74) Agent: SHOWALTER, Barton, E.; Baker & Botts, L.L.P., 2001 Ross Avenue, Dallas, TX 75201-2980 (US).			<b>Published</b> <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>

(54) Title: POINT-TO-MULTIPOINT VARIABLE ANTENNA COMPENSATION SYSTEM

(57) Abstract

An antenna compensation system and method equalizes transmission link efficiency in sectors having unequal antenna or path gain while maintaining an equalized power spectral density. Areas of a sector having lower gains receive broadcasts with more robust coding to equalize their transmission link performance with areas of a sector having higher gains. The robustness of coding is controlled through setting of different forward error code rates, setting of different modulation types, or a combination of both. In analog systems it is controlled through variation of a signal-to-noise sensitive transmission parameter. Sectors may be divided azimuthally with areas at or near the boresight receiving less robust coding and areas nearer the sector edges receiving more robust coding. Similarly, sectors may be divided into radial areas with the more distant areas receiving more robust coding.



**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece	ML	Mali	TR	Turkey
BG	Bulgaria	HU	Hungary	MN	Mongolia	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MR	Mauritania	UA	Ukraine
BR	Brazil	IL	Israel	MW	Malawi	UG	Uganda
BY	Belarus	IS	Iceland	MX	Mexico	US	United States of America
CA	Canada	IT	Italy	NE	Niger	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NL	Netherlands	VN	Viet Nam
CG	Congo	KE	Kenya	NO	Norway	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NZ	New Zealand	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	PL	Poland		
CM	Cameroon	KR	Republic of Korea	PT	Portugal		
CN	China	KZ	Kazakhstan	RO	Romania		
CU	Cuba	LC	Saint Lucia	RU	Russian Federation		
CZ	Czech Republic	LI	Liechtenstein	SD	Sudan		
DE	Germany	LK	Sri Lanka	SE	Sweden		
DK	Denmark	LR	Liberia	SG	Singapore		
EE	Estonia						

POINT-TO-MULTIPOINT VARIABLE  
ANTENNA COMPENSATION SYSTEM

TECHNICAL FIELD OF THE INVENTION

The present invention generally concerns point-to-multipoint wireless communication systems. More particularly, the present invention concerns a point-to  
5 multipoint wireless communication system having one or more antennas providing partial or omnidirectional coverage. The antennas may be sectorized so that each achieves its coverage through plural sectors each covering limited azimuth angles.

BACKGROUND OF THE INVENTION

Point-to-multipoint localized distribution systems are known in the art. Typical systems use multiple low power node antennas, also commonly referred to as cell stations,  
15 base stations, and hub stations, which deliver wireless communication services to receiving stations in an area of coverage, e.g., "cell", defined around the node antennas. The node antennas are arranged to form partially overlapping cells. Frequency differentiation, polarization  
20 differentiation and similar techniques are used alone or in combination to prevent conflicting signals from adversely affecting communications received by receiving stations at or near areas of overlap between adjacent node antennas and between adjacent sectors of a particular node antenna.

25 An interesting point-to-multipoint microwave television distribution system utilizes devices in the millimeter wave frequency band, between about 28 GHz and

300 GHz. Of particular interest is the 29 GHz band, from 27.5 to 31.3 GHz, which provides sufficient width to accommodate a number of broadband channels, avoids previously allocated terrestrial bands, avoids satellite  
5 down-link bands, permits relatively small sized antennas, and is compatible with known low-cost microwave circuit fabrication techniques.

Each antenna in such a system, or in a similar communication system, is required to provide  
10 omnidirectional coverage to form the generally circular cell of transmission coverage around itself. Individual antennas are usually sectorized, so that the omnidirectional coverage is achieved by individual directional sector antennas that cover limited azimuth angles. As an example,  
15 four sector antennas covering adjacent 90 degree sectors may be combined to form an omnidirectional coverage node antenna.

A disadvantage with typical node sector antennas is their nonuniform gain. Their gain commonly varies as a  
20 function of azimuth across the sector and/or as a function of radial distance away from the antenna. Gain is largest near the center of the sector, an area known as the boresight, and gradually lessens at azimuth angles approaching the edges of the sector. As a result, stations  
25 disposed in the boresight receive stronger signals than those disposed at azimuth angles approaching the edges of the sector. Similarly, stations disposed at different radial distances see different antenna gain and different path loss. The stations receiving the lower power signals  
30 are susceptible to signal outage during fading propagation conditions which are associated, for example, with heavy rainfall. In addition, their signal to noise ratio is diminished, producing a higher potential for other types of signal interference. Other systems use radial antennas, or

other types of antennas and share similar problems with receiving stations near adjacent sectors and with receiving stations at different radial distances in the area of antenna coverage.

5           To compensate for differences in antenna and path gain, prior compensation techniques have varied the power supplied to a specific station. This method works well for terrestrial or satellite point-to-point communication systems where frequency reuse is not locally required and  
10       where antennas are separated by large distances. In contrast, it is important to equalize the power spectral density at receiver stations in a point-to-multipoint system so that interference from other node sectors is avoided. For example, when frequency reuse is employed  
15       between node sectors, more than one receiving station is on the same frequency at the node, and the level of sector-to-sector interference is increased by having one signal power density higher than the others that share common frequencies.

20           Thus, there is a need for an improved antenna compensation system for a point-to-multipoint system which addresses the aforementioned difficulties. More specifically, there is a need for an improved antenna compensation system for a point-to-multipoint system which  
25       accounts for variable gain across the azimuth range defining a sector while maintaining equalized power spectral density. Because performance may also vary as a function of radial distance from a node antenna, there is a similar need for an improved antenna compensation system  
30       for a point-to-multipoint system which accounts for variable gain across radial distance while maintaining the equalized power spectral density.

Accordingly, it is a primary object of the present invention to provide an improved antenna compensation

system having a compensated antenna gain pattern and an equalized power spectral density.

Another object is to provide an improved antenna compensation system utilizing multiple forward error  
5 correction code rates to compensate for antenna sector pattern gain differences in azimuth so that receiver stations disposed near sector edges have performance equal to that of receiver stations disposed in sector boresights.

Yet another object is to provide an improved antenna  
10 compensation system utilizing multiple modulation types having different signal transmission efficiencies to compensate for antenna sector pattern gain differences in azimuth so that receiver stations disposed near sector edges have performance equal to that of receiver stations  
15 disposed in sector boresights.

Still another object is to provide an improved antenna compensation system utilizing a combination of multiple forward error correction code rates and multiple modulation  
20 types having different signal transmission efficiencies to compensate for antenna sector pattern gain differences in azimuth so that receiver stations disposed near sector edges have performance equal to that of receiver stations disposed in boresights.

An additional object is to provide an improved antenna  
25 compensation system individually or severally utilizing variable modulation forward error correction code rates and variable modulation types having different signal transmission efficiencies to compensate for antenna pattern gain differences in radial distance so that receiver  
30 stations disposed in radial areas close to the antenna have performance equal to that of receiver stations disposed in radial areas further from the antenna.

A further object of the present invention is to provide an improved analog antenna compensation system in

which a signal-to-noise sensitive transmission parameter is varied to compensate for antenna sector pattern gain differences in azimuth and/or antenna pattern gain differences in radial distance to equalize receiver station performance.

#### SUMMARY OF THE INVENTION

These and other objects are met or exceeded by the present antenna compensation system which equalizes link performance for any equidistant receiver station over each complete node sector azimuth range. Performance gain is realized outside the boresight through more robust transmission to equalize the performance gain throughout an entire sector azimuth range. Robustness varies in inverse proportion to antenna or path gain. A preferred embodiment varies error correction robustness and/or modulation type robustness. Thus, where gain is the highest, e.g. at the boresight, less robust FEC (forward error correction code) or modulation types are used, and where gain falls off, more robust FEC or modulation types are used. Robustness may be similarly varied in analog modulation systems in which a signal-to-noise sensitive transmission parameter may be varied.

A preferred digital antenna compensation system uses a convolution FEC rate  $7/8$  at the boresight. Successive higher performance rates of  $3/4$  and  $1/2$  are used between the boresight and respective edges of the sector. Similarly, a lower eight phase shift key (8PSK) or M-QAM might be used at the boresight and the higher performing quadrature phase shift key modulation type away from the boresight. The result is an equalization of signal performance across the sector. Compensation may also be similarly utilized to equalize performance for gain which varies according to radial distance.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects, features and advantages of the invention will become apparent to artisans upon reading the following detailed description, while referring to the attached drawings, in which:

FIGURE 1 compares typical sector gain compared to an equalized gain achievable through the present invention;

FIG. 2 schematically illustrates a preferred multiple forward error code rate pattern to compensate for gain which varies by azimuth angle across a sector;

FIG. 3 schematically illustrates a preferred multiple forward error code and multiple modulation type pattern to compensate for gain which varies by radial distance from an antenna; and

FIG. 4 is a schematic representation of a preferred compensated point-to-multipoint cellular communication system.

DETAILED DESCRIPTION OF THE INVENTION

Broadly stated, the present invention is directed to an antenna compensation system for equalizing antenna gain azimuthally and/or radially so that an equalized link performance is achieved at receiver stations in various different azimuth and/or radial locations. In a preferred embodiment, variable rate forward error code correction and/or variable modulation types are used with the most efficient correction and modulation being applied in sector areas where antenna gain is the lowest. Link performance is equalized with an equalized power spectral density, thereby permitting 100% frequency reuse. The invention is also applicable to analog transmission antennas in which a signal-to-noise sensitive transmission parameter may be varied.



Turning now to the drawings, and particularly FIG. 1, there is shown a schematic representation of a compensated sectorized node antenna 10 that produces a generally equalized gain 12 azimuthally across sector A. Though various size sectors are possible, the antenna 10 uses a typical pattern of four 90° sectors A-D to achieve omnidirectional, e.g. 360°, coverage. The power spectral density of the antenna 10 is equal throughout the sectors. Gain in sectors B-D is equalized in a similar fashion to that illustrated with respect to sector A. The equalized gain 12 remains generally constant through the complete range of azimuth angles in each of the sectors, whereas uncorrected gain 14 is greatest at the boresight 16 and rolls off near the edges 18 of the sector. Because gain is equalized throughout azimuth angles of the sectors, a receiver station 20 near the sector edge 18 achieves a similar link performance to a receiver station 22 which is radially equidistant from the node antenna 10, but within the boresight 16.

Referring now to FIG. 2, the compensated equalized gain 12 is seen to be preferably achieved by the use of multiple forward error correction code (FEC) code rates R. The particular illustrated embodiment utilizes three different code rates. Two rates produce a rougher equalization, but may be used according to the present invention. Similarly, a smoother equalization may be achieved by use of more than three code rates. As seen in FIG. 2, sector A is divided into 5 areas, with the most robust rate  $R\frac{1}{2}$  used in the two areas adjacent the sector edges, and the least robust  $R\frac{7}{8}$  in the boresight 16. The actual sawtooth gain 24 is calculated to approximate the smooth ideal gain 12 to within about 1 dB. Thus, the embodiment illustrated in FIGS. 1 and 2 provides a method of providing equalized link performance while maintaining

an equalized power spectral density through setting the FEC code rate to be different in different areas of the sector. Multiple FEC rates are illustrated in FIG. 2, but use of different efficiency modulation types can also achieve the generally uniform gain across full sector azimuth range.

Digital communication link performance may be described by the signal to noise ratio required to provide a given bit error rate. The signal to noise ratio is described in terms of  $E_b/N_0$  where  $E_b$  is the signal energy per bit of data transmitted and  $N_0$  is the noise spectral density. Lower  $E_b/N_0$  values for a given bit error rate, such as  $10^{-6}$ , allow better link performance. Where a lower  $E_b/N_0$  meets system bit error rate performance, less power is required at the receiver; whereas higher  $E_b/N_0$  requires more power at the receiver.

This concept is used to the advantage of optimizing the number of channels transmitted in a given allocation of frequency spectrum. The performance for subscribers at different azimuth locations and different radial distances from the antenna is optimized. Geographic orientation to the antenna is used to determine subscriber modulation.

A comparison of modulation  $E_b/N_0$  performance (theoretical) for a few FEC code rates and for multiple Phase Shift Key (PSK) modulation types is described in Table 1.

Table 1

FEC and Modulation	Eb/No Performance for 10 <sup>-6</sup> bit error rate	Relative Performance referred to Rate 3/4 QPSK
Rate 1/2 QPSK	5.0 dB	+1.0 dB
Rate 3/4 QPSK	6.0 dB	0dB
Rate 7/8 QPSK	7.0 dB	-1.0 dB
Rate 2/3 8PSK	7.3 dB	-1.3 dB

As shown in FIG. 2, where antenna gains are lowest at the edge of a sector 18, a Rate 1/2 QPSK system could be used to achieve compensation. At the boresight 16, where antenna gains are highest, the lower performing rate 2/3 with 8PSK or M-QAM modulation could be selected. A rate 3/4 reference code rate was used for comparison. The modulation and code rates are divided up to match the subscriber location in the node azimuth antenna pattern, and for near or far radial distance from the node antenna 10.

An example of a particular azimuth variable antenna compensation pattern according to the invention is described in Table 2 along with the relative performance (theoretical) of various modulation types.

Table 2

Azimuth of Node Antenna	Modulation Type/FEC	Antenna Gain vs Azimuth	Relative FEC Gain	Net Performance
±45 degrees	R1/2 QPSK	10 dB	+ 1.0 dB	11.0 dB
±35 degrees	R3/4 QPSK	12 dB	0dB	12.0 dB
±25 degrees	R7/8 QPSK	13 dB	-1.0 dB	12.0 dB
0 degrees	R2/3 8PSK	15 dB	-1.3 dB	13.7 dB

As seen in Table 2, a 5 dB difference in antenna gain has been compensated to a 2.7 dB difference in net link performance.

Rate  $\frac{1}{2}$  convolution code requires a higher (2X) symbol rate than with no FEC and therefore requires a greater bandwidth at a given data rate for transmission. Rate  $\frac{3}{4}$  code requires 1.33 higher bandwidth than with no FEC. To provide an equalized power spectral density for all modulations, the power must be adjusted according to the code rate and modulation type. It is common to increase modulator output power level with conventional gain control hardware such as attenuators, which may also be software controlled prior to combining. To equalize the Power Spectral Density (PSD), the transmitted power increases with wider bandwidth modulation codes. Higher power on some configurations further enhances the difference in the antenna gain pattern. Table 3 shows the theoretical increase in power for code rate performance and for constant power spectral density. Rate  $\frac{3}{4}$  code is again used for a reference.

Table 3

Modulation Type/FEC	Relative FEC Gain	Relative Power for Constant PSD	Net Code Performance	Performance with Antenna Gain
R1/2 QPSK	+ 1.0 dB	+1.8 dB	+2.8 dB	12.8 dB
R3/4 QPSK	0dB	0 dB	0 dB	12.5 dB
R7/8 QPSK	-1.0 dB	-0.7 dB	-1.7 dB	13.3 dB
R2/3 8PSK	-1.3 dB	-1.3 dB	-2.6 dB	--

The 5 dB antenna roll off described in Table 2 can be compensated by 4.4 dB, to within 0.5 dB, through the use of Rate  $\frac{1}{2}$ ,  $\frac{3}{4}$ , and  $\frac{7}{8}$  FEC rates, with QPSK. In Table 3, the pattern is divided into 3 segments for compensation in place of 4 as was done in Table 2.

Radial variation may also be compensated through the present invention, as illustrated in FIG. 3. As seen in FIG. 3, radial sector areas 26, 28 closer to the node antenna 10 receive less robust coding compensation. Coding

compensation in FIG. 3 is achieved through setting of different code rates/modulation types and includes 8PSK modulation. Power spectral density is similarly equalized here in radial increments.

5           The compensation of the invention is physically realized through modulator control. A specific example is provided in FIG. 4, where separate modems 30 are used to generate respective  $\frac{1}{2}$ ,  $\frac{2}{3}$  and  $\frac{3}{4}$  rates for compensation to receiving stations 20, 22 at different azimuth locations  
10           (22 in boresight, 20 near edge) and for stations 32, 20 or 22 at different radial distances (32 close in, and 22 far out). Other sectors or patterns are compensated in similar fashion according to the invention using conventional combiners, transmitters and antennas.

15           While various embodiments of the present invention have been shown and described, it should be understood that other modifications, substitutions and alternatives are apparent to one of ordinary skill in the art. Such modifications, substitutions and alternatives can be made  
20           without departing from the spirit and scope of the invention, which should be determined from the appended claims.

          Various features of the invention are set forth in the appended claims.

WHAT IS CLAIMED IS:

1. An antenna compensation system comprising:  
at least one antenna having at least one transmission  
sector;

5 transmission means for said at least one antenna for  
transmitting information through said at least one antenna  
to a plurality of discrete areas in its transmission sector  
with equalized power spectral density throughout said  
transmission sector; and

10 equalization means for equalizing transmission link  
efficiency of at least two areas of said transmission  
sector having different gains while maintaining said  
equalized power spectral density throughout said  
transmission sector.

15

2. The system as defined in claim 1, wherein said  
equalization means equalizes transmission link efficiency  
in said at least two areas by setting different forward  
error correction code rates in said at least two areas.

20

3. The system as defined in claim 2, wherein said at  
least two areas comprise separate azimuth ranges in said  
transmission sector and said equalization means sets a more  
robust forward error correction code rate in the azimuth  
25 range having a lower gain.

4. The system as defined in claim 2, wherein said at  
least two areas comprise an area in a boresight of said  
transmission sector and an area adjacent an edge of said  
30 transmission sector, and said equalization means sets a  
more robust forward error correction code rate in the area  
adjacent the edge of said transmission sector than in the  
area in the boresight of said transmission sector.

5. The system as defined in claim 2, wherein three forward error correction code rates are used in five separate azimuth areas in said transmission sector.

5           6. The system as defined in claim 5, wherein a first two of said five azimuth areas are adjacent edges of said transmission sector, a third one is in a boresight of said transmission sector and the remaining two are between the area in the boresight and the areas adjacent edges of the  
10 boresight.

7. The system as defined in claim 6, wherein said equalization means sets a forward error correction code rate of  $\frac{1}{2}$  in said first two areas, a forward error  
15 correction code rate of  $\frac{7}{8}$  in the third area and a forward error correction code rate of  $\frac{3}{4}$  in the remaining two areas.

8. The system as defined in claim 2, wherein said equalization means further sets different modulation types  
20 in said at least two areas.

9. The system as defined in claim 2, wherein said at least two areas comprise separate radial areas in said transmission sector and said equalization means sets a more  
25 robust forward error correction code rate in the radial area which is more distant from said at least one antenna.

10. A method for compensating link efficiency in a point-to-multipoint antenna system having at least one transmission sector with a variable gain, the method comprising steps of:

5       dividing the transmission sector into at least two separate transmission areas according to gain being different in the two separate transmission areas;

10       transmitting signals in said two separate transmission areas with coding of two different efficiencies to equalize link performance in said two separate transmission areas while equalizing the power spectral density in said two separate transmission areas.

11. The method according to claim 10, wherein said  
15       two different efficiencies are accomplished through two different forward error correction code rates.

12. The method according to claim 11, wherein one of  
20       said two separate transmission areas is in a boresight of the transmission sector and the other of said two separate transmission areas is outside the boresight, and signals are transmitted in said one of said two separate transmission areas with a less robust forward error correction code rate than in the other of said two separate  
25       transmission areas.

13. The method according to claim 11, wherein one of  
30       said two separate transmission areas comprises a radial area that separates the other of said two separate transmission areas from a broadcast point for the transmission sector, and signals are transmitted in said one of said two separate transmission areas with a less robust forward error correction code rate than in the other of said two separate transmission areas.



14. The method according to claim 10, wherein said two different efficiencies are accomplished through two different signal modulation types.

5           15. The method according to claim 14, wherein one of said two separate transmission areas is in the boresight of the transmission sector and the other of said two separate transmission areas is outside the boresight, and signals are transmitted in said one of said two separate  
10 transmission areas with a less robust signal modulation type than in the other of said two separate transmission areas.

15           16. The method for equalizing transmission link efficiency according to claim 14, wherein one of said two separate transmission areas comprises a radial area that separates the other of said two separate transmission areas from a broadcast point for the transmission sector, and signals are transmitted in said one of said two separate  
20 transmission areas with a less robust signal modulation type than in the other of said two separate transmission areas.

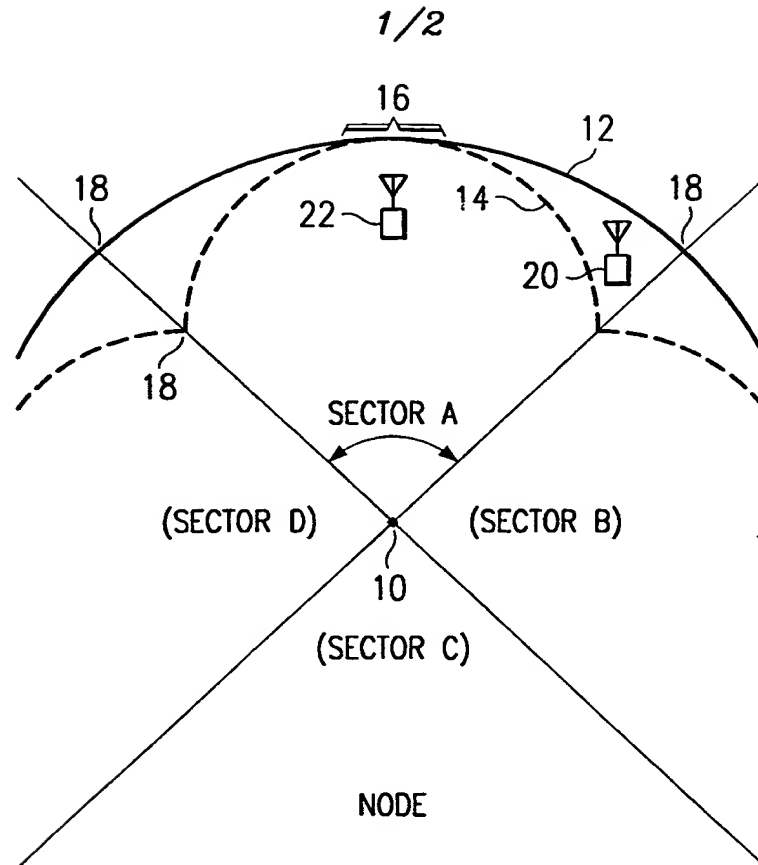


FIG. 1

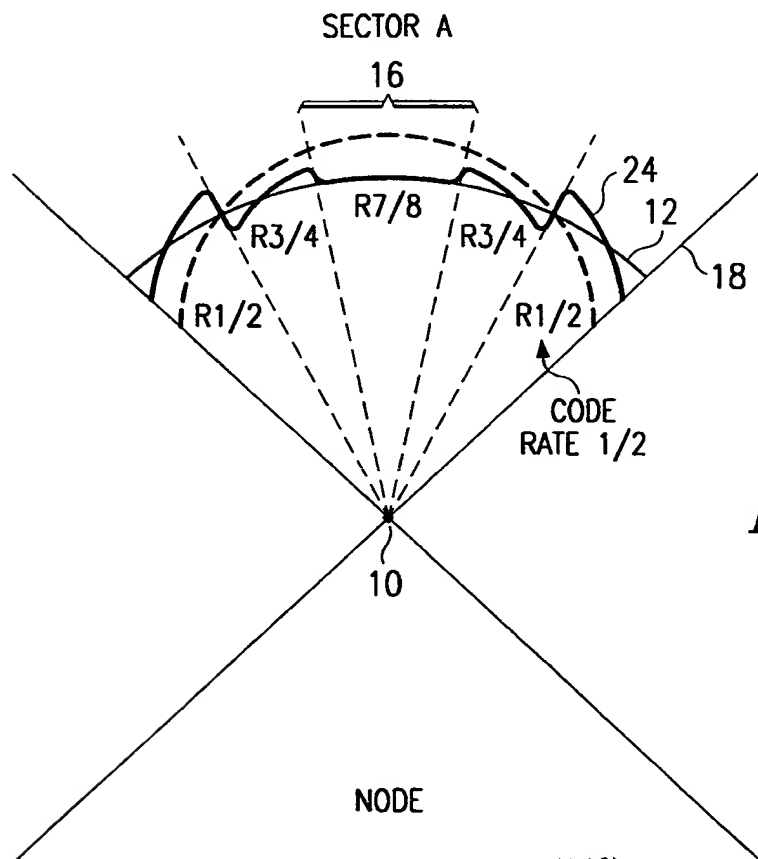


FIG. 2

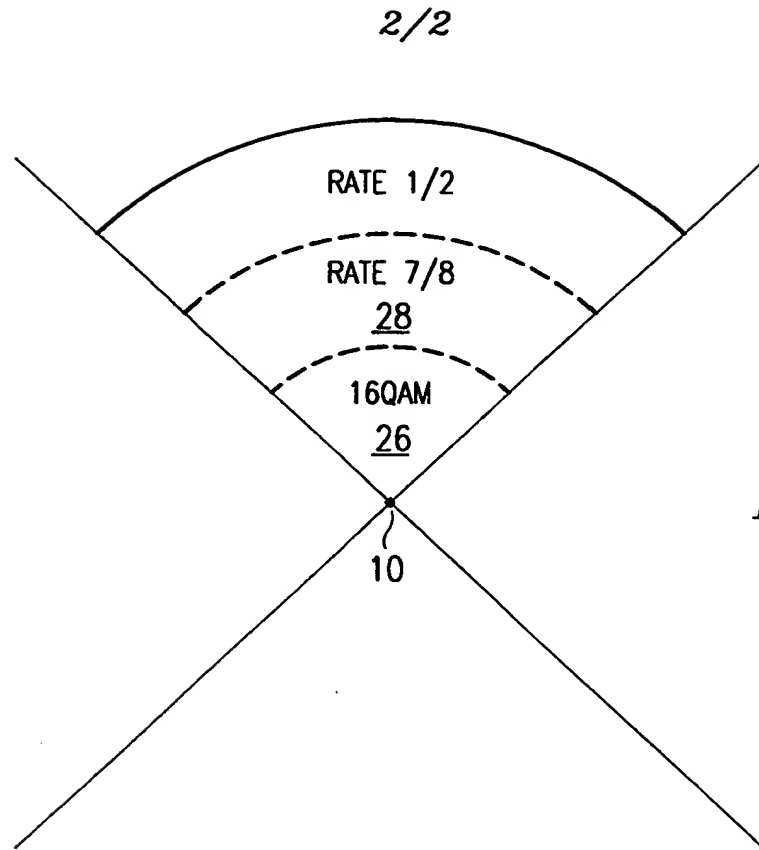
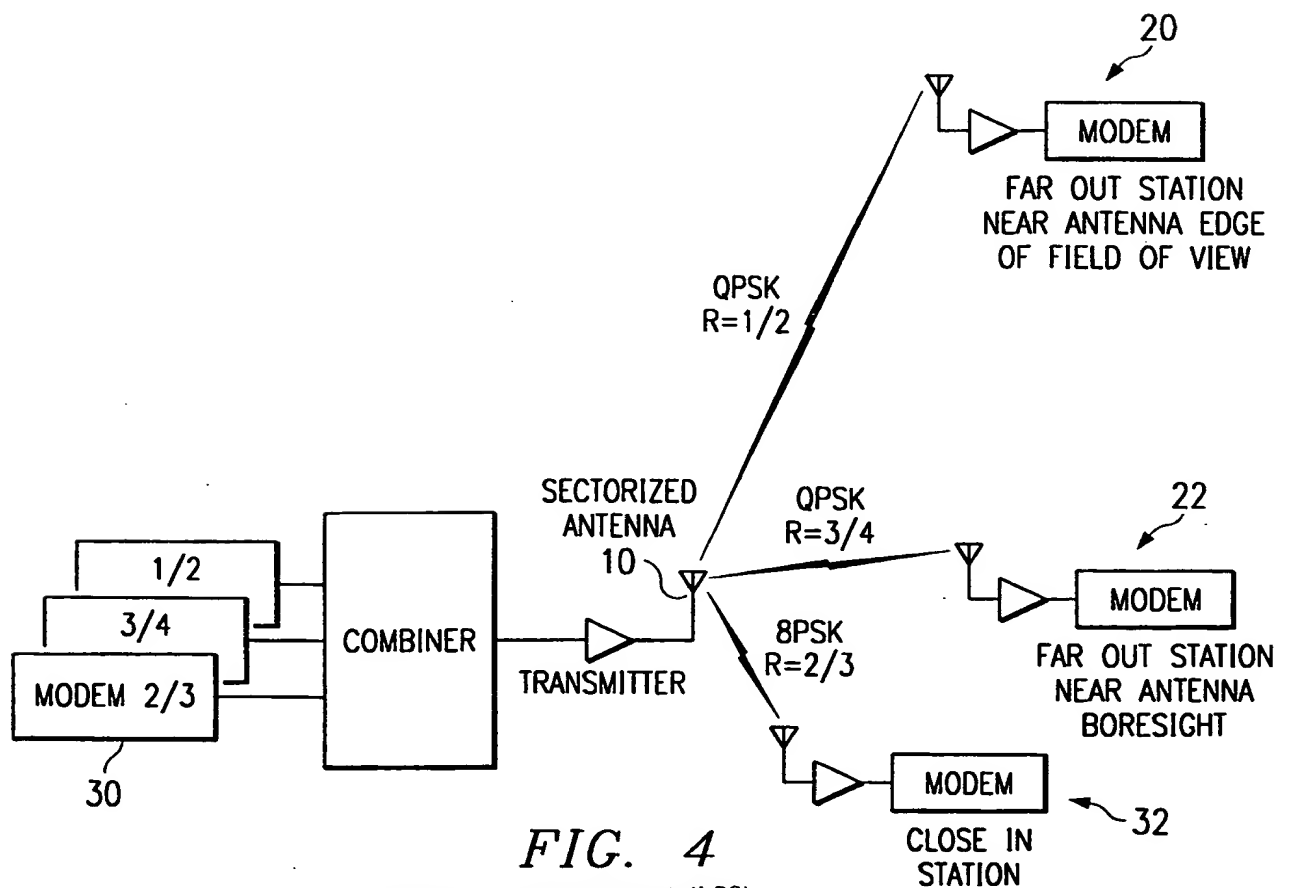


FIG. 3



# INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 99/23328

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 H01Q3/26 H04Q7/36 H04B7/26 H04L1/00

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 H01Q H04Q H04B H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP 0 715 478 A (TEXAS INSTRUMENTS) 5 June 1996 (1996-06-05) column 6, line 50 -column 7, line 39; figures 1,9	1-3, 10-12
Y	US 5 612 948 A (FETTE ET AL.) 18 March 1997 (1997-03-18) column 5, line 35 -column 6, line 58; figures 5-8	1-3, 10-12
A	EP 0 651 531 A (AT&T ) 3 May 1995 (1995-05-03) abstract column 2, line 34 -column 4, line 34; figures 1,2	1-16

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

### \* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

1 March 2000

Date of mailing of the international search report

09/03/2000

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,  
Fax: (+31-70) 340-3016

Authorized officer

Angrabeit, F

# INTERNATIONAL SEARCH REPORT

Int. ...ational Application No  
PCT/US 99/23328

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 90 03071 A (NELSON JOAKIM ;AAHL KARL AXEL (SE)) 22 March 1990 (1990-03-22) page 9, line 8 - line 21 -----	1, 10
A	WO 98 42150 A (AT&T) 24 September 1998 (1998-09-24) abstract; claims 1-5; figures 1-3 -----	1, 10

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 99/23328

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
EP 0715478	A	05-06-1996	EP 0796024 A	17-09-1997
			JP 10084306 A	31-03-1998
			JP 8237181 A	13-09-1996
			US 6006069 A	21-12-1999
US 5612948	A	18-03-1997	NONE	
EP 651531	A	03-05-1995	US 5590405 A	31-12-1996
			CA 2128386 A,C	30-04-1995
			JP 7183873 A	21-07-1995
WO 9003071	A	22-03-1990	AU 635717 B	01-04-1993
			AU 4191189 A	02-04-1990
			DE 68925821 D	04-04-1996
			DE 68925821 T	26-09-1996
			EP 0432198 A	19-06-1991
			JP 4500589 T	30-01-1992
			LV 11074 A	20-02-1996
			LV 11074 B	20-08-1996
			US 5448753 A	05-09-1995
WO 9842150	A	24-09-1998	NONE	